Design, Fabrication and Testing of a Centrifugally Powered Pneumatic Deicing System for Helicopter Rotor Blades

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A novel pneumatic approach to protect helicopter rotor blades from ice accretion is introduced. The system relies on centrifugally generated pressures to deform a 0.508 mm (0.02 in.) thick titanium leading edge cap. The power consumption of the system is therefore negligible. The leading edge cap is protected by a 10 µm (390 microinch) thick Ti-Al-N erosion resistant coating. Beneath the titanium leading edge six (6) pneumatic diaphragms were installed. The diaphragms are normally deflated under vacuum against the surface of the blade, and are inflated when ice accretion thickness reaches a critical value (< 5 mm). The deformation of the leading edge introduces transverse shear stresses at the interface of the ice layer that exceeds the ice adhesion strength of the material (868 KPa, 126 psi), promoting instantaneous ice debonding. The applied input pressures to the system (+/- 25.5 KPa, 3.7 psi) were representative of the pressures that could be generated centrifugally by a medium size helicopter rotor system. With these pressures, the maximum deformation of the leading edge was quantified to be 5 mm (0.2 in). The aerodynamic performance degradation effects related to the leading edge deformation were quantified during low speed (1 M Re) wind tunnel testing. Results were compared to the aerodynamic performance degradation due to ice accretion. It was measured that the penalties related to the deployment of the pneumatic diaphragms was less than the aerodynamic drag penalty of ice accretion by 35%. The lower aerodynamic penalty of deploying the proposed deicing concept with respect to that of ice accretion, indicates that the system would not introduce any aerodynamic penalty while removing accreted ice. The system was tested under representative rotor icing conditions at centrifugal loads that ranged from 110g to 514g. The deicing prototype was successful at promote instantaneous shedding of ice layers ranging from 1.5 to 5 mm (0.06 in. to 0.2 in.) in thickness for varying icing conditions within FAR Part 25/29 Appendix C Icing Envelope.

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